



Design Guideline for Electrical & Electronic Parts used in Satellite Applications to Support Class T and Class J

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1.0 **SCOPE**

This document is intended as a guide to assist a piece part manufacturer with the design and development of electrical and electronic parts intended for satellite and launch vehicle applications. This document is intended to foster improved communication between piece part manufacturers and original equipment manufacturers (OEM). This document is intended to be a living document with ongoing modifications and additions as needed to provide guidance on the satellite application environment.

2.0 **REFERENCE DOCUMENTS**

The following documents apply to parts and processes described herein. They are for reference only.

MIL-STD-202 - Test Method Standard, Electronic and Electrical Component Parts

ASTM E-595 - Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Out-gassing in a Vacuum Environment

3.0 **ENVIRONMENT**

A part should be capable of operating during and after exposure to the following environments. In the following environments, additional self heating is not specified since it is application specific, however it needs to be considered in each application.

3.1 **Thermal Cycling**

The following thermal cycling environment is typical of satellite applications.

3.1.1 During ground operational testing of subassemblies and integrated satellites, parts may be subjected to as many as 50 thermal cycles from -45°C to $+85^{\circ}\text{C}$ with a temperature rate of change as high as $10^{\circ}\text{C}/\text{min}$. Temperature stability is achieved at the temperature extremes.

3.1.2 During on-orbit operations, parts may be subjected to as many as 90,000 thermal cycles. Temperatures inside the satellite range from -35°C to $+60^{\circ}\text{C}$; however, parts inside the satellite are exposed to a temperature differential of 40°C or less within this range. The temperature rate of change may be as high as $3^{\circ}\text{C}/\text{min}$.

3.1.3 During certain operating modes, (e.g., if an orbiting satellite is taken offline), internal temperatures may range from -45°C to $+90^{\circ}\text{C}$ with a temperature rate of change up to $10^{\circ}\text{C}/\text{min}$. There could be up to 100 such operational cycles over the life of a satellite. Parts used on solar arrays or other applications located on outer surfaces of the satellite, such as bypass diodes and temperature sensors, may be exposed to a temperature range of -150°C to $+200^{\circ}\text{C}$ with a temperature rate of change as high as $10^{\circ}\text{C}/\text{min}$. These conditions do not reflect a typical satellite application environment and would normally be determined and specified by the OEM.

3.2 Maximum Temperature

The maximum temperature to which a part may be exposed after manufacture will occur during wave solder or solder reflow. MIL-STD-202, Method 210 describes boundary conditions for this environment. The parts should be capable of withstanding two such cycles during original manufacture, plus two additional cycles during rework.

3.3 Vibration

During transportation modes and during launch, a part will be exposed to a vibration environment. The actual environment at the part varies depending upon location, structural features and characteristics, etc., of the application. The boundary conditions for the vibration environment is a variable frequency vibration covering the frequency range of 20-2,000 Hz, with a peak acceleration of 20 g.

3.4 Constant Acceleration

During launch, a part may be exposed to a constant acceleration as high as 12 g in any axis.

3.5 Mechanical Shock

Due to the use of pyrotechnics to perform separation functions, parts may be exposed to mechanical shocks. The actual mechanical shock and the direction of the shock at the part varies depending upon proximity to pyrotechnic devices, satellite structural features and characteristics, etc., of the application. The boundary conditions for the mechanical shock environment is a 1,500 g peak level shock with a 0.5 ms pulse duration.

3.6 Rapid Depressurization

Parts should be capable of withstanding a rapid depressurization of 1 atm/min without damage.

3.7 Moisture

Parts should be capable of withstanding typical manufacturing operations. Piece part manufacturers should expect OEMs to handle, prepare for assembly in equipment, and store per the piece part manufacturers' instructions. After assembly to the next highest level of integration, parts may be exposed to moisture during normal ground transportation, storage, and assembly. Parts should be capable of withstanding a condensing environment. The part should not be degraded or damaged after exposure.

3.8 Radiation

A part may be exposed to the entire spectrum of radiation energy. The radiation environment in space has several components: trapped electrons and protons in the Van Allen belts, galactic cosmic rays, and protons and electrons from both solar flares and coronal mass ejections. The particular environment for a satellite depends on its altitude, inclination and mission duration. In addition, the actual radiation environment that a part may be exposed to will depend on the amount of inherent shielding provided by the satellite. As a result, radiation effects should be considered on a case by case basis since there are many variables associated with the actual radiation environment that a part may experience. These issues should be resolved between the device manufacturer and the OEM.

4.0 DESIGN CONSIDERATIONS

4.1 Package

Packages should be compatible with automated assembly operations. The industry trend is towards surface mount packages. The variety of package configurations should be minimized.

4.2 Outgassing

Materials used in construction of a part should have a Total Mass Loss (TML) of less than 1.0% and a Collected Volatile Condensable Material (CVCM) of less than 0.1% when tested in accordance with ASTM E-595.

4.3 Operating Life

Active devices should be designed to have an operating life of at least 15 years when operated at a junction temperature of +55°C for devices with power ratings of less than 1 Watt or +105°C for devices with power ratings greater than 1W. Passive devices should be designed to have an operating life of at least 15 years when operated at a case temperature of +85°C.

4.4 Power Cycling

A part should be designed to withstand 100,000 on-off power cycles of the applied bias to the device in its application.

4.5 Design Recommendations

The following design features and materials should be avoided:

- a. Formed cap-to-header hermetically sealed cases, and stud mount cases.
- b. Point contact or whisker diode construction.
- c. Electrical crystal mounting at less than three locations around the crystal periphery.
- d. Non-solid electrolytic (wet slug) in capacitors.
- e. Pure Tin coatings, except that electrical/electronic part terminals and leads may be coated with a tin alloy containing not less than 3% lead only when necessary for solderability.
- f. Silver plating.
- g. Cadmium, zinc, or selenium, except internal to hermetically sealed parts with leak rates less than 1×10^{-4} atm-cm/sec².
- h. Mercury and mercury compounds.
- i. Polyvinylchloride.

- j. Materials subject to reversion.
- k. Materials which evolve corrosive compounds.
- l. Materials which sublime.

5.0 DESIGN VERIFICATION

The part manufacturer should ensure that each new design is qualified for its intended market. The method of qualification and the qualification results should be made available to the OEM.

5.1 Reliability

Parts should have inherently high reliability since satellite rework or repair is essentially impossible. Failures-in-Time (FIT) rates for parts intended for satellite use should be as low as possible. The following table lists target FIT rates for various part types. In calculating FIT rates, a confidence level of 60% should be used, as well as a case temperature of +55°C for devices with power ratings under 1 Watt and +105°C for devices with power ratings over 1 Watt. In addition, the basis of the part family that the FIT rate is calculated against should be communicated with the OEM.

5.1.1 Part Type Targeted FIT Rate

- a. Diode 1 FIT
- b. Transistor 1 FIT
- c. Microcircuit10 FIT
- d. Hybrid50 FIT

6.0 Notes

A model for calculating part reliability from life test data is contained in EIA SSB-1 "Guideline for Using Plastic Encapsulated Microcircuits and Semiconductors in Military, Aerospace and Other Rugged Applications."

This document was developed by The EIA JEDEC G-12 Committee with Government and Industry involvement to support Class T product as defined in MIL-PRF-38535 and Class J product as defined in MIL-PRF-19500 for satellite type applications.

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